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Extent of Climate Information Service as a Decision Support Tool to Climate Smart Agricultural Technology Use and Adoption in Ghana

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ABSTRACT

Climate information services have been crucial in the quest to promote sustainable agricultural production. Access to information is a first step in addressing such a situation. In this context, getting information on events, actions, situations, or happenings that threaten the achievement of sustainable agriculture production is the top most priority. Climate information received by farmers is critical to farmers decision making and planning process in the agriculture sector specifically with productivity, food security, plant and soil health. Use and adoption of CSA technologies by farmers is largely influenced by inherent decisions based on climate information at all stages of production. Based on this, 679 farmers across 6 regions in Ghana, rainfall onset, first cessation, windstorm, humidity, drought spell and rainfall volume were identified as the CI required in order of importance out of nine (9). Out of all the farmers that accessed this information, about 72% had information on rainfall onset being the highest, followed by first-cessation with 47%. This top 2 is largely possible because of the heavily dependence of rainfall on agriculture and through farmer-to-farmer information sharing, and much focus on rain related information. CSA adoption, a little above one-fifth (22%) of the farmers adopted crop rotation. Pest and disease tolerant varieties were adopted by 15% of the farmers, with a close to equal adoption percentage across all three sampled groups. Minimum tillage was reported as a male-dominant CSA and was only adopted by less than one-fifth of the total respondents. Enhanced biopesticide use was male dominant. CIS proves to be a critical tool for decision making and hence influence CSA use and adoption. This therefore requires strong improvement in both content, strategy and approach to delivering tailor-made CI for farmers and other value chain actors.

INTRODUCTION

Climate information services have been crucial in the quest to promote sustainable agricultural production. Getting information on any situation is the first step in addressing such a situation. In this context, getting information on events, actions, situations, or happenings that threaten the achievement of sustainable agriculture production is the topmost priority. This study then recorded the climate information received by farmers since climate change largely affects the agriculture sector and most especially productivity, food security, welfare, plant and soil health. From the climate information services (CIS) received by the farmers, some actions were taken to adapt to the negative impact associated with each of the climate information services. The action plan or adaptative strategies were the use of Climate-Smart Agriculture (CSA).

Ghanaian agriculture has significant challenges due to climate change, which makes using climate-smart agricultural (CSA) technologies necessary. These technologies are to augment productivity, enhance resilience, and mitigate greenhouse gas emissions. Djido et al. (2021) reported that for better implementation and adoption of Climate smart agriculture first find climate information that helps in addressing climate change.

Climate Information Services (CIS) entail the creation, packaging, and distribution of climate data that supports agricultural decision making. Farmers in Ghana obtain CIS from the Ghana Meteorological Agency, Multinational organizations, NGOs, and others through various channels, including radio, extension services, telephones, television and the mass media (Weniga Anuga et al., 2019; Sarku et al., 2021) . However, the usefulness of CIS as a decision-making tool is dependent on multiple factors. Access to real-time, location-specific information, the ability to analyze and apply data, and the integration of conventional knowledge with scientific forecasts are all essential for realizing the benefits of CIS (Harvey et al., 2021).

CIS studied by several researchers indicated the potential and how important CIS in adopting CSA technologies. Accessing accurate and timely climate information is essential for farmer in making informed decisions from land preparation to planting and filed management through to harvesting and post-harvest handling (Antwi-Agyei & Nyantakyi-Frimpong, 2021; Rebecca, 2021). To reduce the possible crop failures linked to various climate risks. Seasonal climate projections too enable farmers to select appropriate crops varieties and activities that matches with the projected climatic conditions (Zougmoré et al., 2018).

It is demonstrated that, the incorporation of CIS into agricultural decision-making processes can considerably increase the use of CSA technology. Damba et al. (2024) found that farmers who utilize CIS regularly are inclined to adopt improved agricultural technologies and practices. The study discovered a link between CIS use and the adoption of drought-resistant crops, better soil management practices, and effective irrigation systems. Also, farmers who bundled weather forecasts and agro-advisories were more inclined to adopt and use CSA practices like improve varieties for drought and pest and diseases, proper irrigation systems, and integrated soil fertility and pest management (Partey et al., 2020). The information allows them to optimize resource utilization, reduce associated losses and increase yield for ultimate contribution to food security and livelihood.

Despite all the potential advantages, a number of challenges prevent Ghanaian farmers from utilizing CIS. Nyadzi et al. (2022) performed a survey across many regions of Ghana and discovered that, while farmers are aware of CIS, their actual use differs greatly. The notable challenges across studies were restricted access to reliable and timely information, low farmer literacy, inadequate infrastructure for distribution, high cost of communication devices and the usefulness of the information delivered(Fosu-Mensah et al., 2012; Affram, 2021). It also prevails that, socio-cultural settings like gender dynamics, determines how groups can access and use CIS. All this play important roles in determining the extent of CIS utilization. Successful case studies demonstrate how CIS has a positive impact on CSA technology adoption in Ghana. The International Crop Research Institute for the Semi-Arid Tropics (ICRISAT) and its partners have showed considerable improvements in farmers' decision-making process through the Participatory Integrated Climate Services for Agriculture (PICSA) strategies. Farmers received training on how to read and use climate information through PICSA, which leads to increased adoption of CSA practices and better agricultural production (Ky-Dembélé et al., 2020).

The utilization of CIS as a decision tool is critical for the adoption of CSA technologies in Ghana. While progress has been made in expanding CIS, significant challenges remain. Addressing these challenges through targeted investments, capacity-building initiatives, and inclusive policy frameworks can enhance the effectiveness of CIS and promote the widespread adoption of climate-smart agricultural practices. The integration of CIS into agricultural decision-making processes holds great promise for building a resilient and sustainable agricultural sector in Ghana.

MATERIALS AND METHODS

Study Area

The study was conducted across six regions in Ghana (Figure 1), focusing on the role of Climate Information Services (CIS) in promoting sustainable agricultural production. The regions were characterized by diverse agricultural activities heavily reliant on rainfall, which underscores the critical importance of climate-related information in decision-making processes for farmers. A total of 679 farmers participated in the study, highlighting the significance of various climate indicators.

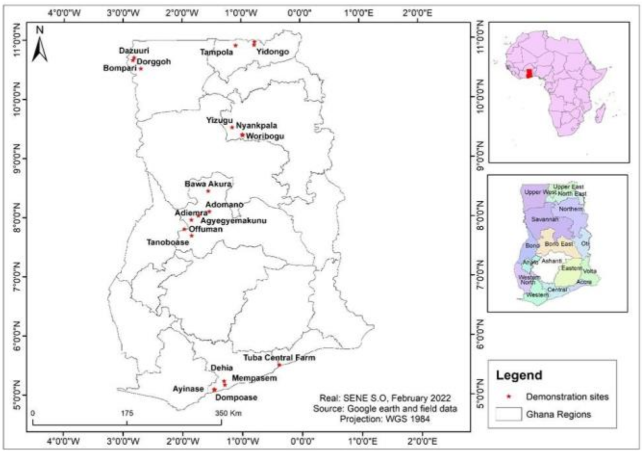

Figure 1: Map of the Study Communities and Regions

The underpinning theory of this study was random utility maximization theory. Farmers or individual decision-makers, being rational, maximize their utility based on choices. Farmer i in making their choices considers m_i alternatives that are exclusive j in making their choice set I^i. The farmer i then assigns utility U_j^i to the alternatives in their choice set and then pick the one that gives them the maximum utility. The i being the individual farmer and j being their choice of adaptation strategies. The strategies include; on-farm composting, enhanced biopesticides, minimum tillage, dual purpose cowpea variety, seedbed ridging, vine technology, seed multiplication, stress tolerant variety, pest and disease tolerant variety, crop rotation and minimum staking.
Based on the count nature of the various CIS and CSA technologies, a farmer has an option of selecting from a set of n CSA technologies within a season. These choices are based on the utility derived from these technologies and climate information services (CIS). We assessed the effect of nine climate information options available to farmers in the study area. Farmers used and adopted various CI in count form. Hence the Poisson model was appropriate for the data an individual farmer has an option to choose from the nine climate information options.
The utility assigned to the choices are each dependent on other factors or attributes of the farmer and expressed in a formular as;

$$U_j^i = U^i(X_j^i) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

where X_j^i is the explanatory variable contributing to the adaptative strategies j utility by the farmer.
At this point, the certainty of a farmer in selecting a particular adaptation strategy can be predicted. The probability of selecting strategy j depends on the farmers choice set I^i, giving that the probability of perceived utility of adaptative strategy j being greater than other strategies U_k^i.

$$\wp^i\left[\frac{j}{I^i}\right] = \wp r[U_j^i > U_k^i \quad \forall k \neq j, k \in I^i \ldots..(2)$$

The perceived utility U_j^i is given by vectors or combination of systemic utility V_j^i and random residual ϵ_j^i thus the deviation of perceived utility by farmer i. This represented as;

$$U_j^i = V_j^i + \epsilon_j^i \quad \forall j \in I^i \ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

DATA

A total of 679 farmers were interviewed from 32 communities across 6 regions comprising of pilot CSA technologies sites, network farmers and controlled farmers. Table 2 below shows the regions, districts and communities where the study was conducted. To avoid homogeneity and a spillover of information to and from the treated and the control groups, a 12-km distance was ensured to select controlled communities. A third group of respondents known as networking farmers was drawn from the treated communities to capture farmer-farmer learning. This approach was to assess the level of diffusion of technologies during implementation. Respondents were drawn from previous climate change interventions as well as other existing projects and interventions undertaking the identified CIS-CSA technologies in 6 regions of Ghana.

Table 1: Study regions, districts and specific communities along value chains

Region	District/Municipality	Communities	Commodity
Greater Accra	Ga South	Tuba	Vegetables (Tomatoes, Pepper, Cabbage)
Central	Cape Coast Metropolitan	Mempeasem	Sweet potato
		Effutu Dehyia	Sweet potato
	Komenda-Edena-Eguafo-Abrem	Dompoase	Sweet potato, maize and cowpea

		Enyinase	Sweet potato
Bono East	Kintampo North	Adomano	Yam, maize
		Bawakura	Yam
	Kintampo South	Adiemra	Yam, maize
		Agyegyemakunu	Yam
	Techiman North	Offuman	Yam, maize, cowpea
		Tanoboase	Yam
Northern	Tolon	Nyankpala	maize, cowpea
		Woribog	maize, cowpea
		Yizeigu	maize, cowpea
Upper East	Kasena Nankana District	Tampola	Maize, cowpea
	Bongo District	Yidongo	Maize, cowpea,
Upper West	Lawra	Boompari	Maize, cowpea
		Dzuuri	Maize, cowpea
	Jirapa Municipal	Doggoh	Maize, cowpea

Socio-demographic Characteristics of respondents

As shown in Table 2 below, estimates of the descriptive statistics of the respondents revealed that majority of the respondents were married (82.24%). Majority of the respondents had no formal education with about 26.32% having primary education and the least being tertiary education level.

The demographic characteristics of the farmers as showed in Table 1 indicates that about half (48.36%) of them have not received any form of formal education, and about a quarter (26.32%) had primary or basic education. Secondary and tertiary education were only obtained by close to 20% and 5%, respectively. This level of education indicates poor educational accessibility among farmers, with close to half not accessing formal education.

Farming communities in Ghana are mostly rural communities (Abdul-Rahaman & Abdulai, 2020), which are characterized by lower educational status. Azumah et al. (2023) also reported 52% not having formal education. It was also realized that a larger portion (83.23%) of farmers were married, contributing to the average household size of five (5) people. The observed mean age of the farmers was around 47 years old, with the least and maximum age being 21 and 95 years, respectively. As reported by Anang et al., (2020); Dagunga et al., (2020); Kwapong et al., (2021); Jayne et al., (2022) and Ayamga et al., (2023), the average land holdings for farming activities in rural areas are around 6 acres; but this study reported less, between 3.4 acres and 5.8 acres respectively. This is largely due to the fragmentation of the land among generations according to Kwapong et al., (2021) but Azumah et al. (2023) attributed decreased farm sizes to the patriarchal inheritance of lands in Ghana thus, a disadvantage to female with less access to land compared to their male counterparts.

Table 2a: Descriptive statistics of the respondents

Marital Status	Percent
Single	6.58
Married	82.24
Divorced	4.61
Widowed	6.58
Total	**100**
Level of Education	**Percent**
No formal education	48.36
Primary education	26.32
Secondary education	20.39
Tertiary	4.61
Other levels	0.33
Total	**100**

Table 2b: Acres of Land Cultivated

Control	Male	Mean	Min	Max
		4.5		
	Female	3.4		
Network	Male	5.8		
	Female	4.4		
Treated	Male	4		
	Female	3.5		

Variable	Mean	Std. dev.	Min	Max
Age	47	13.97	21	95
Household Size	5	0.996	5	20

Source: Field Data Estimation (2024)

In terms of the socio-demographic characteristics of the respondents, most of them were married with no formal education (48.36%). Male farmers in all the 3 categories had on average 0.5 to 1 acre more land for farming purposes compared to the female. In terms of age, average age was 47 years with an average house size of 5 members per household.

RESULTS AND DISCUSSION

Extent of CIS Influence on CSA Technology Adoption

The results on Table 3 below indicate that all farmers that access climate information services are certain to have at least used one (1.478) climate-smart adoption option as compared to those who did not have access to climate information services.

There are other variables that influence climate-smart agriculture use and adoption. The poison estimates of the regression adjustment model revealed that the age of a farmer contributes negatively (-0.005) to the adoption of climate-smart agriculture technologies. As age is a decreasing function of performing rigorous activity, all the technologies that are energy intensive are out of older farmers access, limiting the number of technologies at their disposal. Accounting for the reduction in adoption of CSA technology as farmers are ageing.

Table 3: CIS influence on CSA technology Adoption

CSA ADOPTED	Coefficient	std. errs.	z	P>z
ATE CIS access (Yes vs No)	1.4776	0.2874597	5.14	0.00
POmean CIS access (No)	0.2386151	0.2818998	0.85	0.397
POISSON OUTCOME				
Age	-0.0047679	0.0024914	-1.91	0.056
Education	0.0091105	0.0970478	0.09	0.925
Household size	-0.0130093	0.0112168	-1.16	0.246
Land size (acres)	-0.003383	0.0057059	-0.59	0.553
Farm distance (kg)	-0.0151395	0.0201007	-0.75	0.451
Financial access	0.3651483	0.0672424	5.43	0.000
Extension access	0.1168194	0.0707179	1.65	0.099
Agriculture research participation	0.111282	0.0668406	1.66	0.096
FBO	0.163082	0.0785057	2.08	0.038
Years of climate information	0.0385924	0.0109449	3.53	0.00
Constant	0.3744763	0.1870707	2.00	0.045
Treatment-effects estimation Estimator: regression adjustment Outcome model: Poisson Treatment model: none		Number of observations = 679		

Source: Author's Estimation (2024).

Financial access with a coefficient (0.365) explains that farmers who accessed financial assistance were found to have increased CSA technology adoption relative to those who could not access financial assistance. Reflecting some of the CSA technologies requires financial commitment, increasing the financial burden of the farmers. Farmers who also had access to agricultural extension services were more likely to increase their CSA technology adoption relatively due to the training and reinforcement of their knowledge they received from the agents, being indicated by the positive coefficient (0.117).

Also, farmers participation in agricultural research resulted in the increase (0.111) in the number of CSA technologies adopted, as this research sometimes unveils new CSA technologies and builds their capacities to adopt these technologies. Farmers who belonged to farmer-based organizations were relatively more likely to increase CSA technologies adopted. From the group setup, farmers mostly get training and support from organized bodies, more farmer-to-farmer knowledge sharing, labour sharing, and, among other things, helped them increase their adoption efforts.

Lastly, the number of years a farmer has been receiving climate information services also significantly increases (0.039) the possibility of adopting more CSA technologies. As years go by, the understanding of the information and approaches of addressing/utilizing such information increases, leading to adopting more CSA technology options, as it happens to be one of the best approaches in the agricultural production process.

Climate Information Accessed by Farmers

It is evident in Figure 2 below that farmers' in the study area accessed nine (9) climate information services (CIS) for various seasonal purposes. Out of the nine (9) CIS accessed, about 72% had information on rainfall onset, followed by first-cessation with 47%. These top 2 are largely possible due to the heavily dependence on rainfall for agriculture and through farmer-to-farmer information sharing, and much focus on rain related information (Bessah et al., 2021; Cudjoe et al., 2021; Akobeng, 2022; Kumi et al., 2023; Agoungbome et al., 2023). Windstorms were accessed by 35% of the farmers, humidity or sunshine by 22%, drought or dry spells by 18%, rainfall amount by 12%, information on pests and diseases was accessed by 8% of the farmers, flooding by 4%, and temperature by 2%. The reason for such low access is largely because of limited infrastructure for accurate and reliable research for information and dissemination, lower literacy rate among farmers, higher extension to farmer ratio, and language barrier (Guido et al., 2020; Kawarazuka et al., 2020; Mkenda et al., 2020; Autio et al., 2021; Ncoyini et al., 2022).

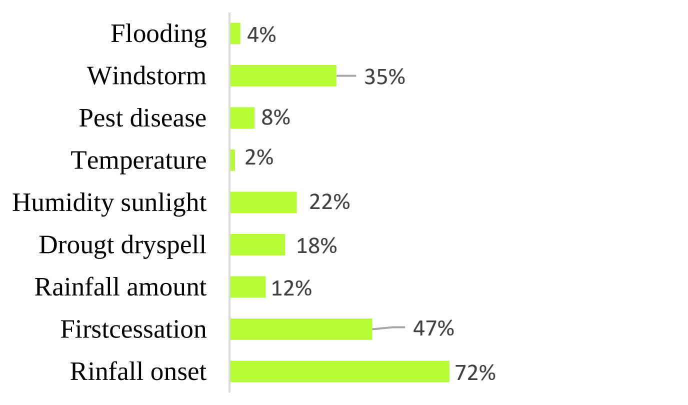

Figure 2: Climate Information Services accessed by farmers

Rainfall-onset Information-led CSA

Climate information on rainfall onset from Figure 3 compelled the farmers who received this information to adopt the following CSA's. About a third (27.52%) adopted stress-tolerant improved varieties, being the highest, followed by one in five (23.2%) for crop rotation, 18.69% for pest and disease-tolerant varieties, 16.02% for enhancement of biopesticide use, and 15.61% for minimum tillage. On-farm composting, seedbed options ridging, dual-purpose cowpea, seed multiplication technologies (mini-sett, aeroponics, and hydroponic), vine technology, and minimum staking or trellis to reduce deforestation, were all adopted by approximately less than 5% of the farmers.

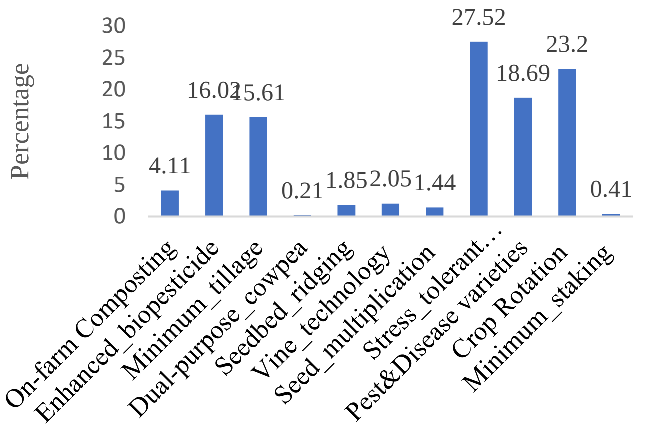

Figure 3: Rainfall-onset information led adaptations (CSA's)

First-Cessation Information Led Adaptations (CSA's)

From Figure 4, climate information on first cessation led to about 44.62% of farmers accessing and using stress-tolerant varieties, 32.91% adopted crop rotation, 23.1% adopted pest and disease tolerance, 16.14% adopted minimum tillage, 10.44% adopted enhanced biopesticide use, and 5.7% adopted on-farm composting, but seedbed options ridging, dual-purpose cowpea, seed multiplication technologies (mini-sett, aeroponics, and hydroponic), vine technology, and minimum staking/trellis to reduce deforestation were all adopted by approximately less than 5% of the farmers.

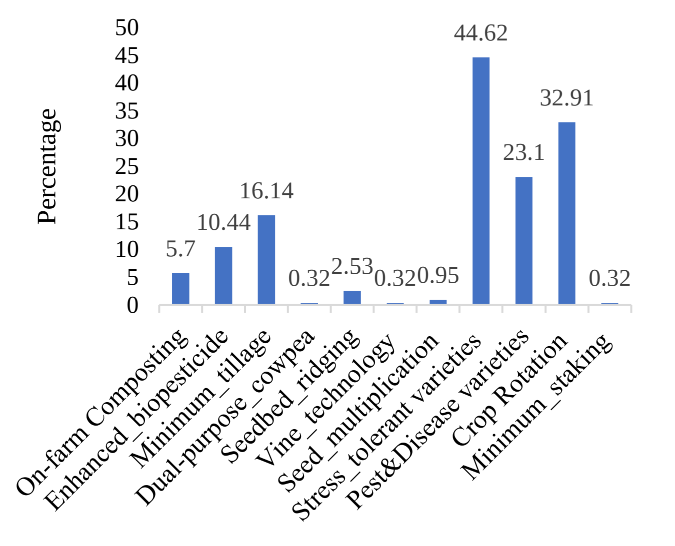

Figure 4: First-cessation information led adaptations (CSA's)

Rainfall Amount Information-Led CSA Technology Adaptations

Annual rainfall volume per season as shown in Figure 5 influenced 53.75% farmers decision to adopt minimum tillage, 22.5% for enhanced biopesticides, 20% for stress-tolerant improved varieties, 18.75% for crop rotation, 8.75% for pest and disease-tolerant cultivars, and 6.25% for seed multiplication respectively. Less than 5% of farmers used minimum staking, seedbed ridging, vine technology, and on-farm composting based on information on rainfall amount.

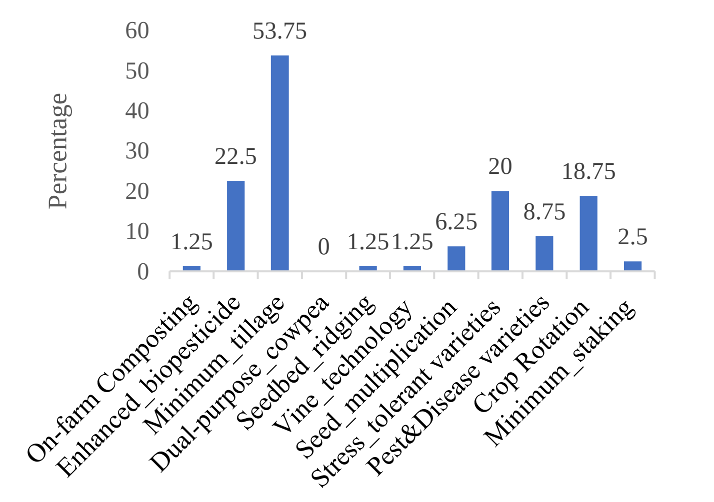

Figure 5: Rainfall amount information led adaptations (CSA's

Humidity/Sunlight Information Led Adaptations (CSA's)

The primary adaptation strategy or CSA adopted by farmers after receiving humidity and sunshine information, as shown in Figure 6, was stress-resistant improved varieties by 38.26%. Crop rotation was followed by pest and disease-tolerant varieties (31.54%), enhanced biopesticide use (22.15%), minimum tillage (16.78%), and on-farm composting (6.71%). Dual-purpose cowpea, seedbed ridging, and minimum staking were adopted below 5%.

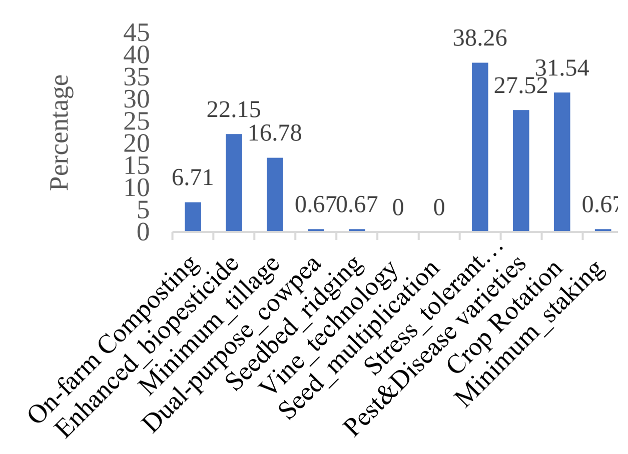

Figure 6: Humidity or Sunlight Information Led

Drought or dry-spell Information Led Adaptations (CSA's)

From Figure 7 below, drought and dry spell information led to about 21.14% of the farmers adopting enhanced biopesticide use; 17.07% adopted pest and disease-tolerant varieties; 13.01% adopted minimum tillage; 11.38% adopted crop rotation; and 4.88% adopted on-farm composting. Stress-tolerant improved varieties, seed multiplication, and vine technology were all adopted below 2%. It is noted that prolonged dry spells or droughts make crops stressed and more susceptible to pests and diseases. This reflects why farmers adopted pest and disease-tolerant varieties and enhanced biopesticide use for further control. A suspected higher level of moisture reduction makes farmers refrain from practices that will expose the soil too much. This makes farmers embrace minimum tillage and crop rotation, which involve cover crops like cowpea. All this signifies the adoption of the top 4 CSAs in Figure 7.

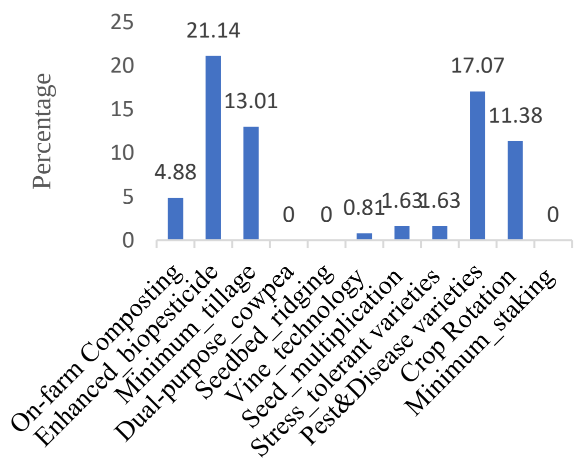

Figure 7: Drought or Dry-spell Information Led Adaptations (CSA's)

Pest and Diseases Information Led Adaptations (CSA's)

Pest and disease information guided farmers adaptation strategies as shown in Figure 8 below with about 30.91% of farmers adopting pest and disease-tolerant varieties; 25.45% adopted crop rotation; 20% adopted enhanced biopesticide use; 7.27% adopted minimum tillage; 5.45% adopted on-farm composting; and 1.82 adopted seed multiplication respectively. There is evidence that among the adaptative strategies for pest and disease information, pest and disease-tolerant varieties, stress-tolerant improved varieties, enhancing biopesticide use, and rotating from infested land to prevent crop underperformance are very important to farmers.

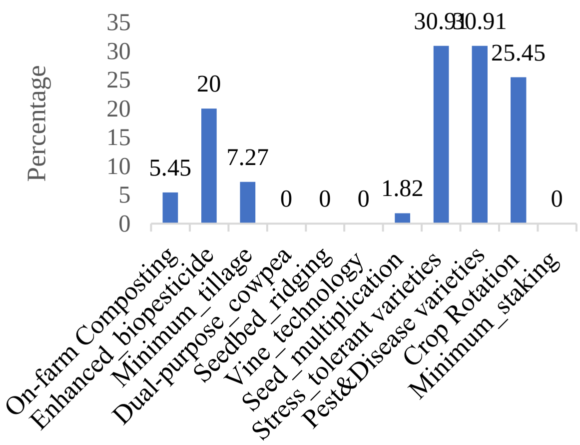

Figure 8: Pest and diseases information led adaptations (CSA's)

Flooding Information Led Adaptations (CSA's)

Flooding has been a big, life-threatening occurrence in this era of climate change. It has been robbing people of their means of survival, causing a lot of food insecurity among farming households (Opoku Mensah et al., 2023). We studied the post-flood's information climate adaptive strategies adopted by farmers. Results from Figure 9 indicates that out of all the farmers that received information on flooding, about 58.33% adopted crop rotations, possibly due to heavy water-required crops in the possible flooding areas. Improved stress-tolerant cultivars were adopted by about 41.67% of farmers, on-farm composting by 33.33%, enhanced biopesticide use by 29.17%, and crop rotation by 16.67% of farmers. Farmers were observed to be not adopting minimum or conservational tillage to preserve soil nutrients and seedbed ridging to prevent some crops from being submerged in water. This resulted in a drop in crop output, which in turn affected the availability of food and ultimately caused food insecurity. The level of implementation of these practices has to be improved and promoted.

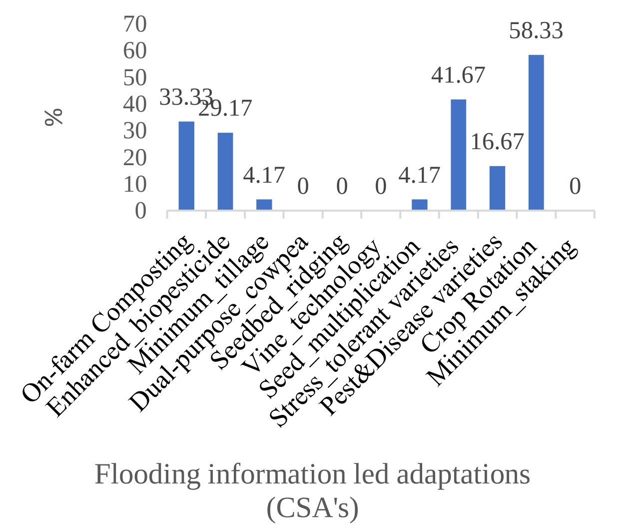

Figure 2: Flooding information led adaptations (CSA's)

Temperature Information Led Adaptations (CSA's)

Information on increasing temperatures that affect crops, as reported by farmers in Figure 10, was responded to by adopting improved variety selection: 50% for pest and disease and 42% for stress tolerance. It was also shown that about 25% adopted crop rotation, 16.67% adopted enhanced biopesticide use, and 8.33% adopted minimum tillage. Increasing temperatures require soil moisture conservation practices like intercropping with cover crops (Nyawade et al., 2019). The results in this section demonstrate that related, temperature-resistant practices were not given any priority, including the use of dual-purpose cowpeas, vine technology, and composting to increase soil organic matter. The percentage of farmers that adopted the applicable CSA after hearing concerning temperature changes was also low, as was the minimum or conservation tillage. As temperature affects sustainable production and food security status, the uptake of most of those CSAs must be promoted.

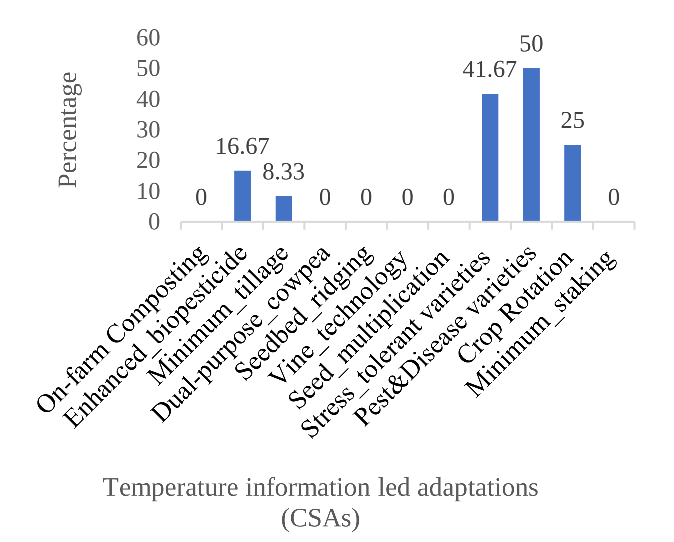

Figure 3: Temperature information led adaptations

Windstorm Information Led Adaptations (CSA's)

On receiving information on windstorms, the farmers adopted those CSAs, as shown in Figure 11. About 27% of the farmers adopted minimum tillage, 23.21% adopted enhanced biopesticide use, 12.12% adopted stress-tolerant improved varieties, 12.66% adopted pest and disease-tolerant varieties, and about 8.44% adopted crop rotation. On-farm composting, dual-purpose cowpea seedbed ridging, vine technology, and minimum tillage were the least focused areas for windstorm information. Notwithstanding, crop variety selection that could shorten the maturity days and rotation of crops to more wind-resilient crops to reduce the impact were not comprehensively adopted. In order to reduce the vulnerability of farmers to windstorms, immense sensitization should be carried out on crop variety selection, crop rotation, and all associated practices.

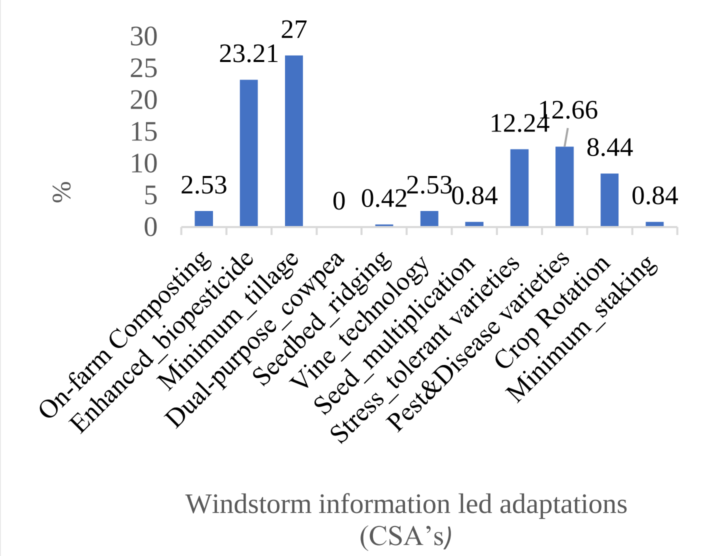

Figure 4: Windstorm information led adaptations (CSA's)

Climate Smart Agriculture (CSA) Technology Adoption

Climate-Smart Agriculture adoption was measured on a sampled group and sex-specific basis based on the different dimension and utility derived from each technology used. The pooled adoption for all the CSAs as presented in Table 4 below shows that none of the CSAs was adopted by more than a quarter of the total respondents. This in general is very low, depending on the adverse climate impact on agriculture in recent times. Specifics of the CSAs adoption indicated that stress-tolerant improved varieties were the most adopted, with about 24% of respondents, and the leading sampled group in adoption was the AICCRA participant. The sex segregation also showed female adoption dominance among the sampled group that had benefited from the AICCRA project, directly or indirectly. About a little above one-fifth (22%) of the farmers adopted crop rotation, and it was shown that female AICCRA participants adopted about 2% more compared to their male counterparts. Pest and disease tolerant varieties were adopted by 15% of the farmers, with a close to equal adoption percentage across all three sampled groups. Minimum tillage was reported as a male-dominant CSA and was only adopted by less than one-fifth of the total respondents. Enhanced biopesticide use was male dominant, adopted by 15% of the male AICCRA participants, but female dominant in the network group, adopted by 18%. The remaining CSAs were each adopted by less than 10% of the farmers, and the least adopted was the minimum staking by 1% of the farmers.

Table 4: Sample Group and Gender Specific CSA Adoption

		Treated participant	Network	Controlled-distant	Pool 1	Pool 2
PDV	Male	0.17	0.12	0.17	0.15	0.15
	Female	0.12	0.17	0.10	0.14	
STV	Male	0.28	0.25	0.18	0.32	0.24
	Female	0.32	0.27	0.08	0.25	
EHB	Male	0.15	0.12	0.07	0.11	0.12
	Female	0.13	0.18	0.10	0.14	
OFC	Male	0.03	0.05	0.06	0.05	0.04
	Female	0.04	0.03	0.00	0.03	
DC	Male	0.06	0.07	0.10	0.08	0.07
	Female	0.10	0.03	0.00	0.05	
RT	Male	0.23	0.22	0.25	0.23	0.22
	Female	0.25	0.20	0.10	0.19	
MT	Male	0.13	0.16	0.17	0.15	0.14
	Female	0.06	0.10	0.17	0.10	
SM	Male	0.08	0.04	0.02	0.04	0.04
	Female	0.00	0.06	0.00	0.03	
VT	Male	0.03	0.12	0.04	0.06	0.07
	Female	0.14	0.07	0.00	0.08	
MST	Male	0.03	0.02	0.01	0.01	0.01
	Female	0.00	0.00	0.00	0.00	

OFC = On-farm Composting, EHB = Enhanced biopesticide, MT = Minimum tillage, DC = Dual-purpose cowpea, SBR = Seedbed ridging, VT = Vine technology, SM = Seed multiplication, STV = Stress tolerant varieties, PDV = Pest and Disease varieties, RT = Crop Rotation, MST = Minimum staking

CSA technology adoption among farmers as presented in Figure 12 showed skewedness towards climate stress resistance practices. The adoption of stress-tolerant improved varieties leads to the adoption of climate smart technologies among most farmers (24%). Followed by crop rotation, which was adopted by 22% of the pest and disease-tolerant varieties, minimum tillage, and the last among the five CSAs, enhanced biopesticide use, representing 12% of the farmers.

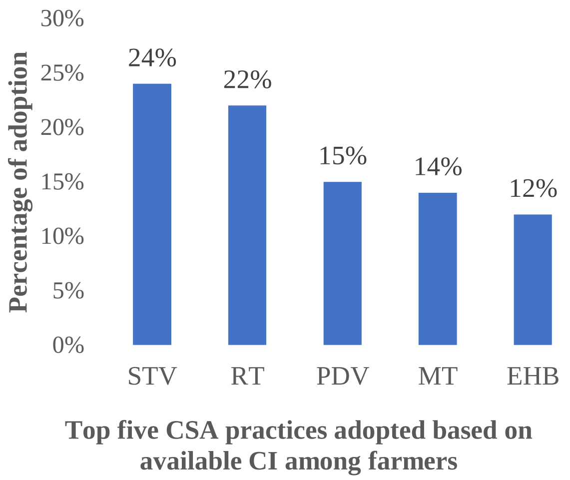

Figure 5: Top five CSA practices adopted based on available CI among farmers

Findings further revealed that farmers adopt same CSA technologies irrespective of the whether there is a project intervention or not. This was evident in the findings of the study where project beneficiary farmers adopted same technologies as non-beneficiary farmers in the same locality. This shows that, farmers would use and adopt a given technology based on the intended purpose of usage, that is, increased productivity, mitigation and adaption abilities of a CSA technology. Stress tolerance improved the adoption levels for project beneficiary and network farmers by 31% and 25% respectively, attributed to awareness and food security measures. Crop rotation was adopted by 23% of direct beneficiaries and network farmers. Followed by pest and disease tolerance, enhanced biopesticide use, and the least among the top 5 was minimum tillage. The highest adopted CSA technologies among controlled distant farmers was minimum tillage, with only about 17% of the farmers adopting it. This practice has been adopted by farmers as a traditional agronomic practice, and its relative ease of practice justifies high-rate adoption. The least control distance for farmers was the promotion of dual-purpose cowpea as this technology is new among farmers. The adoption of the CSAs among female farmers took the same positions as the general adoption, with stress-tolerant improved varieties leading with 25% adoption and the least being minimum tillage with 10% adoption.

CONCLUSION

It is evident that climate information is critical to the use and adoption of climate smart agricultural technologies in Ghana. Critical to CSA use and adoption is information on rainfall onset for decision and choice of CSA technology to use in a particular season. Added to this CI, first season is also critical to farmers and other users of climate choice as a decision criterion since it further confirms farmers decision on the choice of CSA technology in Ghana. Gender role sums up the confirmation and based on the labor-intensive nature of most CSA technologies, decisions around CSA technologies also critical choices added to onset and first season. It is therefore critical for service providers and regulators of CIS in Ghana to deliver customized CIS for informed decision towards choice of CSA in Ghana.

CONFLICT OF INTEREST

The author declares that there is no conflict of interest regarding the publication of this paper.

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